LEGEND: **DRAFT 10/04/16**
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Black bold text is added from 10 States Standards Chapter 70 2014.
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Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—Design Guides

10 CSR 20-8.160 Settling.

PURPOSE: This amendment will update the rule to current industry practices.

PURPOSE: The following criteria have been prepared as a guide for the design of settling tanks. This rule is to be used with rules 10 CSR 20-8.110[–] ***through*** *10 CSR 20-8.2[2]****1****0 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission [as]* ***in*** *regard[s]* ***to*** *adequacy of design, submission of plans, approval of plans, and approval of completed [sewage works]* ***wastewater treatment facilities. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of all ASTM International standards pertaining to settling tanks and appurtenances, design manuals such as Water Environment Federation's Manuals of Practice, and other wastewater treatment facility design manuals containing principles of accepted engineering practice.*** *Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from* ***the 2014 edition of the*** *Great Lakes-Upper Mississippi River Board of State [Sanitary Engineers]* ***and Provincial Public Health and Environmental Managers*** *Recommended Standards for [Sewage Works]* ***Wastewater Facilities*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. [Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.]*

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms **"**shall**"** and **"**must**"** are used, they are to mean a mandatory requirement insofar as approval by the *[agency]* **Missouri Department of Natural Resources (department)** is concerned, unless justification is presented for deviation from the requirements. Other terms, such as **"**should**"**, **"**recommend**"**, **"p**referred**"** and the like, indicate *[discretionary requirements on the part of the agency and deviations are subject to individual consideration]* **the preference of the department for consideration by the design engineer**.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(B) Clarifier. Clarifiers are settling tanks with mechanical means for continuous removal of solids deposited by sedimentation. A clarifier is generally used to remove solid particulates or suspended solids from liquid or clarification or thickening. Sludge collects at the bottom of the tank, or sludge hopper, and is removed.
(C) Freeboard. Freeboard is the vertical distance from the normal water level surface to the top of the tank.
(D) Scum. Scum is particles that float to the surface of the liquid.
(E) Side Water Depth. Side water depth is the vertical distance from the top of the overflow weir to the top of the sludge hopper.
(F) Sludge Hopper. A sludge hopper is the lowest point of a settling tank where sludge accumulates and is removed.

[(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).]

(2) Applicability. This rule shall apply to all wastewater treatment facilities with settling.
(A) This rule shall not apply to animal feeding operations, animal manure management systems, or other agricultural waste management systems. Design guide and criteria for these facilities are found in 10 CSR 20-8.300 and 10 CSR 20-8.500.

(3) General *[Considerations]*.
(A) Number of Units. Multiple **settling** units capable of independent operation are desirable and shall be provided in all *[plants]* **wastewater treatment facilities** where design **average** flows exceed one hundred thousand (100,000) *[gpd (379m^3/d)]* **gallons per day**. *[Plants]* **Wastewater treatment facilities without** *[not having]* multiple **settling** units shall **be designed to** include other provisions to assure continuity of treatment. **The design should consider provisions for future installation of settling units.**
[(B) Arrangement. Settling tanks shall be arranged in accordance with subsection 10 CSR 20-8.140(5)(E).]
*[(C)]***(B)** Flow Distribution. Effective flow *[measurement]* **splitting** devices and control appurtenances (*[that is, valves,]* **i.e.,** gates, splitter boxes, etc.) shall be provided to permit proper proportion**ing** of flow **and solids loading** to each **settling** unit**, throughout the expected range of flows**. **Refer to 10 CSR 20-8.140(5)(H).**
[(D) Tank Configuration. Consideration should be given to the probable flow pattern in the selection of tank size and shape, and inlet and outlet type and location.]

(4) Design *[Considerations]*.
(A) Dimensions.
1. The minimum length of flow from inlet to outlet *[should]* **shall** be ten feet (10') *[(3 m)]* unless special provisions are made to prevent short*[-]* circuiting. *[The sidewater depth for primary clarifiers shall be as shallow as practicable, but not less than seven feet (7') (2.1 m). Clarifiers following the activated sludge process shall have sidewater*

depths of at least twelve feet (12') (3.7 m) to provide adequate separation zone between the sludge blanket and the overflow weirs. Clarifiers following fixed film reactors shall have sidewater depth of at least seven feet (7') (2.1m).]

2. The vertical side water depths shall be designed to provide an adequate separation zone between the sludge blanket and the overflow weirs. The minimum side water depths shall be as follows in Table 160-1, included herein:

Table 160-1. Minimum Side Water Depth

Type of Settling Tank	Minimum Side Water Depth (ft)
Primary	**10**
Secondary tank following activated sludge process [1]	**12**
Secondary tank following attached growth biological reactor [1]	**10**

[1] Greater side water depths are recommended for secondary tanks in excess of four thousand square feet (4,000 ft^2) surface area (equivalent to seventy feet (70') diameter).

(B) Surface *[Settling Rates (]*Overflow Rates*[)]*.

[1. Primary settling tanks. Surface settling rates for primary tanks should not exceed one thousand (1000) gpd per square foot (41m^3/m^2/day) at design average flows or one thousand five hundred (1500) gpd per square foot (61m^3m^2/day) for peak hourly flows. Clarifier sizing shall be calculated for both flow conditions and the larger surface area determined shall be used. Primary settling of normal domestic sewage can be expected to remove thirty to fifty percent (30–50%) of the influent BOD. However, anticipated BOD removal for sewage containing appreciable quantities of industrial wastes (or chemical additions to be used) should be determined by laboratory tests and consideration of the quantity and character of the wastes.]

1. Primary setting tanks. Primary settling tank sizing should reflect the degree of solids removal needed and the need to avoid septic conditions during low flow periods. Sizing shall be calculated for both the design average and design peak hourly flow conditions, and the larger surface area determined shall be used. The following surface overflow rates in Table 160-2, included herein, should not be exceeded in the design:

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Table 160-2. Primary Settling Tank Surface Overflow Rates

Type of Primary Settling Tank	Surface Overflow Rates at: [1] Design Average Flow (gpd/ft^2)	Design Peak Hourly Flow (gpd/ft^2)
Tanks not receiving waste activated sludge [2]	**1,000**	**2,000 – 3,000**
Tanks receiving waste activated sludge	**700**	**1,200 – 1,700**

Comment [ETC1]: Reference Metcalf & Eddy Table 5-20.

[1] **Surface overflow rates shall be calculated with all flows received at the settling tanks. Primary settling of normal domestic wastewater can be expected to remove approximately one-third of the influent BOD when operating at an overflow rate of one thousand gallons per day per square foot (1,000 gpd/ft^2).**

[2] **Anticipated BOD removal should be determined by laboratory tests and should consider the character of the wastes. Significant reduction in BOD removal efficiency will result when the peak hourly overflow rate exceeds one thousand five hundred gallons per day per square foot (1,500 gpd/ft^2).**

2. Intermediate settling tanks. Surface *[settling]* **overflow** rates for intermediate settling tanks following series units of fixed film reactor processes *[shall]* **should** not exceed one thousand five hundred *[(1500) gpd per square foot (61m^3/m^2/day)]* **gallons per day per square foot (1,500 gpd/ft^2)** based on **the design** peak hourly flow. **Higher surface settling rates to one thousand five hundred gallons per day per square foot (1,500 gpd/ft^2) based on the design peak hourly flow may be permitted if such rates are shown to have no adverse effects on subsequent treatment units.**

3. Final settling tanks **– pilot test**. Settling tests *[should]* **shall** be conducted wherever **a** pilot study of biological treatment is warranted by unusual waste characteristics**,** *[or]* treatment requirements*[.]***, or** *[Testing shall be done]* where proposed loadings go beyond the limits set forth in this *[section]* **rule**. **Refer to 10 CSR 20-8.140(5)(B) for pilot testing requirements.**

4. Final settling tanks – attached growth biological reactors. Surface *[settling]* **overflow** rates for settling tanks following trickling filters *[or rotating biological contractors]* shall not exceed one thousand two hundred *[(1200) gpd]* **gallons per day** per square foot *[(49m^3/m^2/day)]* **(1,200 gpd/ft^2)** based on **the design** peak hourly flow.

5. Final settling tanks – activated sludge. *[Final settling tanks following]* **To perform properly while producing a concentrated return flow,** activated sludge *[processes must]* **settling tanks shall** be designed to meet thickening *[as well as]* **and** solids separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or re*[-]*aeration tanks is quite high in activated sludge processes, **the** surface *[settling rate]* and weir overflow rate**s** should be [adjusted] **adjustable** for the various processes to minimize the problems with sludge loadings, density currents, inlet hydraulic turbulence**,** and occasional poor sludge settleability. *[The*

hydraulic design of intermediate and final settling tanks following activated sludge processes shall be based upon the anticipated peak hourly rate for the area downstream of the inlet baffle. The hydraulic loadings shall not exceed—one thousand two hundred (1200) gpd per square foot (49m^3/m^2/day) for conventional, step aeration, contact stabilization and the carbonaceous stage of separate-stage nitrification; one thousand (1000) gpd per square foot (41m^3/m^2/day) for extended aeration; and eight hundred (800) gpd per square foot (33m^3/m^2/day) for the separate nitrification stage. The solids loading for all activated sludge processes shall not exceed fifty pounds (50 lbs.) solids per day per square foot (244 kg/m^2/day) at the peak rate. Consideration should be given to flow equalization.] **The size of the settling tank shall be based on the larger of the surface areas determined for surface overflow rate based on the design peak hourly flow and solids loading rate. The following design criteria in Table 160-3, included herein, shall not be exceeded:**

Table 160-3. Activated Sludge Final Settling Tank Rates

Treatment Process	Surface Overflow Rate at Design Peak Hourly Flow [1] (gpd/ft^2)	Peak Solids Loading Rate [2] (lb/day/ft^2)
With diurnal flow equalization [3]	1,000	-
Without diurnal flow equalization [3]	150	-
Conventional, Step Aeration, Complete Mix, Contact Stabilization, Carbonaceous Stage of Separate Stage Nitrification	1,200 [4]	40
Extended Aeration Single Stage Nitrification	1,000	35
Two (2) Stage Nitrification	800	35
Activated Sludge with Chemical addition to Mixed Liquor for Phosphorus Removal	900 [5]	35

[1] **Based on influent flow only.**
[2] **The peak solids loading rate shall be calculated based on the design maximum day flow rate plus the design maximum return sludge rate requirement and the design mixed liquor suspended solids under aeration.**
[3] **Applicable to wastewater treatment facilities with a design average flow of less than one hundred thousand gallons per day (100,000 gpd).**

Comment [ETC2]: 10 CSR 20-8.020(12)(B)7.B. The maximum surface settling rate at peak rates of flow with flow equalization shall not exceed one thousand gallons per day per square foot (1,000 gpd/ft^2) for domestic type wastewater. For plants without flow equalization, the maximum surface settling rate shall not exceed one hundred fifty gallons per day per square foot (150 gpd/ft^2) at the twenty-four (24)-hour average design flow.

[4] **Wastewater treatment facilities needing to meet twenty milligrams per liter (20 mg/L) suspended solids should reduce the surface overflow rate to one thousand gallons per day per square foot (1,000 gpd/ft^2).**

[5] **When phosphorus removal to a concentration of less than one milligram per liter (1 mg/L) is required.**

(C) Inlet Structures.

1. Inlets **and baffling** *[should]* **shall** be designed to dissipate the inlet velocity, to distribute the flow equally**,** both horizontally and vertically**,** and to prevent short*[-]* circuiting.

2. Provision of flocculation zones shall be evaluated for secondary settling tanks.

3. Channels *[should]* **shall** be designed to maintain a velocity of at least one foot (1') per second *[(0.3m/s)]* at one-half (1/2) the design **average** flow.

4. Corner pockets and dead ends *[should]* **shall** be eliminated**.** *[and c]***C**orner fillets or channeling **shall be** used where necessary.

5. Provisions shall be made for elimination or removal of floating materials **that may accumulate** in inlet structures.

(D) Weirs.

1. General. Overflow weirs shall be **readily** adjustable *[for leveling]* **over the life of the structure to correct for differential settlement of the tank**.

2. Location. Overflow weirs shall be located to optimize actual hydraulic detention time, and minimize short*[-]* circuiting. **Peripheral weirs shall be placed at least one foot (1') from the wall.**

*[3. Design rates. Weir loadings should not exceed**:** ten thousand (10,000) gpd per lineal foot (124m^3/m/day) for plants designed for average flows of 1.0 mgd (3,785m^3/day) or less. Higher weir loadings may be used for plants designed for larger average flows but should not exceed fifteen thousand (15,000) gpd per lineal foot (186m^3/m/day). If pumping is required, weir loadings should be related to pump delivery rates to avoid short-circuiting.]*

3. Design rates. The following weir loadings in Table 160-4, included herein, shall not exceed:

Table 160-4. Weir Loading Rates

Average Wastewater Treatment Facility Capacity	**Loading Rate at Design Peak Hourly Flow (gpd/lf)**
< 0.1 MGD	**10,000**
0.1 MGD – 1 MGD	**20,000**
> 1 MGD	**30,000**

4. Pumping. If pumping is required, the pumps shall be capable of operating as continuously as possible. Also, weir loadings should be related to pump delivery rates to avoid short circuiting.

Comment [ETC3]: Stakeholder comment: What does this entail?

Comment [ETC4]: What do you think of using > < symbols to describe the capacities or should it be spelled out?

Comment [ETC5]: Stakeholder question why the increase from 10,000 to 20,000 gpd/lf?

WEF Clarifier Design 2nd Edition – "Experience of many operators and design engineers has led to a general agreement that substantially higher weir loading rates would not impair performance, provided other design parameters are selected consistent with good design practice."

*[4.]***5.** Weir troughs. Weir troughs shall be designed to prevent submergence at *[maximum]* design **peak hourly** flow and to maintain a velocity of at least one foot (1') per second *[(0.3m/s)]* at one-half (1/2) *[the]* design **average** flow.

(E) Submerged Surfaces. The tops of troughs, beams**,** and similar submerged construction elements shall have a minimum slope of 1.4*[:]* **vertical to one horizontal***[;]* **(1.4:1).** *[t]***T**he underside of *[the]* **such** elements *[should]* **shall** have a slope of one to one (1:1) to prevent the accumulation of scum and solids.

(F) Unit De*[-]*watering.

1. Unit de*[-]*watering features shall conform to the provisions outlined in 10 CSR 20-8.140(6)**(C)**.

2. The unit isolation design *[should also]* **shall** provide for *[re]*distribution of the *[plant]* **facility** flow to the remaining **settling** units. **Refer to 10 CSR 20-8.140(6)(B).**

(G) Freeboard. Walls of settling tanks shall extend at least six inches (6") *[(15 cm)]* above the surrounding ground surface and shall provide not less than twelve inches (12") *[(30 cm)]* **of** freeboard. Additional freeboard or the use of wind screens is recommended where larger settling tanks are subject to high velocity wind currents that would cause tank surface waves and inhibit effective scum removal.

(5) Sludge and Scum Removal.

(A) Scum Removal. Effective **surface** scum collection and removal facilities, including baffling, shall be provided for all settling tanks. The unusual characteristics of scum *[which]* **that** may adversely affect pumping, piping, sludge handling and disposal *[should]* **shall** be recognized in design. Provisions *[may]* **shall** be made *[for the discharge of scum with the sludge; however,]* **to remove scum from the wastewater treatment process and direct it to either a scum concentrator or to the sludge treatment process.** *[o]***O**ther special provisions for **scum** disposal may be necessary.

(B) Sludge Removal. **Mechanical** *[S]***s**ludge collection and withdrawal facilities shall be *[so]* designed *[as]* to assure rapid removal of the sludge. Suction withdrawal should be provided for activated sludge *[plants designed for reduction of the nitrogenous oxygen demand and is encouraged for those plants designed for carbonaceous oxygen demand reduction]* **facilities with settling tanks over sixty feet (60') in diameter, especially for activated sludge facilities that nitrify**. **Each settling tank shall have independent sludge withdrawal lines to ensure adequate control of sludge wasting rates for each tank.**

1. Sludge hopper. The minimum slope of the side walls shall be 1.7*[:]* **vertical to one horizontal (1.7:1)**. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum dimension of two feet (2') *[(.6m)]*. **Sludge hoppers with** *[E]***e**xtra depth *[sludge hoppers]* for sludge thickening are not acceptable.

2. Cross-collectors. Cross-collectors serving one (1) or more settling tanks may be useful in place of multiple sludge hoppers.

3. Sludge removal *[piping]* **pipeline**. Each **sludge** hopper shall have an individually*[-]* valved sludge withdrawal line at least six inches (6") *[(15 cm)]* in diameter **for gravity withdrawal and four inches (4") in diameter for pump suction. Sludge return air lift**

Comment [ETC6]: 10 CSR 20-8.020(12)(B)7.E. A baffle shall be provided at the outlet, within six inches (6") of the effluent trough and extended four to eight inches (4" - 8") below and six inches (6") above the liquid level.

Comment [ETC7]: 10 CSR 20-8.020(12)(B)7.C. Tank hoppers should have a minimum side slope of sixty degrees (60°) to the horizontal and bottoms not in excess of one foot (1') square or one foot (1') in diameter. In computing detention capacity of non-mechanical hopper tanks, only the upper one-third (1/3) (by height) of the hopper(s) may be included. Tank hoppers should be considered as commencing when two (2) or more sides have a side slope of sixty degrees (60°) to the horizontal. Dual hoppered tanks should provide a minimum water depth of two feet (2') over the junction of sixty degrees (60°) walls between hoppers. The installation of more than two (2) hoppers per settling tank will not be accepted.

piping shall be at least three inches (3") in diameter. The static head available for withdrawal of sludge shall be thirty inches (30") *[(76 cm)]* or greater as necessary to maintain a *[three]***two**-foot (*[3]***2**') per second *[(0.9m/s)]* velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the hopper walls shall be sufficient to prevent **"**bridging**"** of the sludge. Adequate provisions shall be made for rodding or back-flushing individual pipe runs. **Provisions shall be made to allow for visual confirmation of return sludge.** Piping shall *[also]* be provided to return *[waste]* sludge *[to primary clarifiers]* **for further processing**. **Refer to 10 CSR 20-8.170(7)(B).**
4. Sludge removal control. **Separate settling tank sludge lines may drain to a common sludge well.** Sludge wells equipped with telescoping valves or other appropriate equipment shall be provided for viewing, sampling**,** and controlling the rate of sludge withdrawal. *[The use of easily maintained sight glass and sampling valves may be appropriate.]* A means of measuring the sludge removal rate shall be provided. Air-lift *[type of]* sludge removal will not be approved for **the** removal of primary sludges. *[Sludge pump motor control system shall include time clocks and valve activators for regulating the duration and sequencing of sludge removal.]*

Comment [ETC8]: 10 CSR 20-8.170(7)(B) draft 6/3/16:
"Sludge withdrawal piping should have a minimum diameter of 8" for gravity withdrawal and 4" for pump suction and discharge lines. Where withdrawal is by gravity the available head on the discharge pipe should be at least 4' greater than the calculated head loss. All sludge piping systems shall be designed to provide a velocity of at least 2 fps."

(6) Protective and Service Facilities.

(A) *[Operator]* **Facility Personnel** Protection. All settling tanks shall be equipped to enhance safety for *[operators]* **facility personnel**. *[These]* **Safety** features shall appropriately include machinery covers, life lines, stairways, walkways, handrails**,** and slip*[-]* resistant surfaces. **Also refer to 10 CSR 20-8.140(9).**

(B) Mechanical Maintenance Access. The design shall provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal*[,]* mechanism**,** *[and]* baffles, weirs, inlet stilling baffle area**s,** and effluent channels.

(C) Hosing Equipment. Hosing equipment for routine flushing of walls and walkways at all facilities shall be provided. Where water supply is not available, a pump with hose connection may be used. Refer to 10 CSR 20-8.140(8)(D) for wastewater treatment facility water supplies.

*[(C)]***(D)** Electrical **Equipment,** Fixtures**,** and Controls. Electrical **equipment,** fixtures**,** and controls in enclosed settling basins **and scum tanks, where hazardous concentrations of flammable gases or vapors may accumulate,** shall *[be suitable for hazardous locations ()]* **meet the requirements of the** National Electrical Code for Class I, *[Group D,]* Division 1**, Group D** location*[)]***s**. The fixtures and controls shall be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting shall be provided.

(7) High-Rate and Chemically Enhanced Settling. High-rate and chemically enhanced settling units shall be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these units should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater. Refer to 10 CSR 20-8.140(5)(B) for pilot testing requirements.

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(8) Supplement to the Summary of Design. The summary of design shall contain the following information in addition to that required in 10 CSR 20-8.110(5):

(A) Hydraulic detention time;
(B) Surface overflow rates at design peak hourly flow;
(C) Peak solids loading rate; and
(D) Weir loading rate at design peak hourly flow.

Comment [ETC9]: Is there anything additional that needs to be included from 8.110(5) (i.e. sizing, rates, velocities, diagrams, etc. for all individual process units)? If so, ideas of what to include?

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979. *Original authority 1972, amended 1973, 1987, 1993.*